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4.1 The geological history of England and its landscape

The geological evolution of the earth began around 4.6 billion years ago and the oldest rocks found in Britain are older than 570 million years. The geological timescale is sub-divided into eras, periods and stages. Many of the names given to world-wide geological time units originate from English place names or type localities (reference sites with which all rocks of a similar age and geological type can be compared). As such the geological history of England is internationally significant.

Upland areas are the result of millions of years of geological activity. Some upland areas were created by the uplift, folding and faulting of rocks as oceans closed and continents collided during the geological evolution of Britain. Others were never affected by these mountain building episodes and exist as uplands simply because they are formed of rock that is more resistant to erosion than the surrounding geology. All of them have been affected by the Ice Age that swept across the country.

A vast range of geological and geomorphological interest is found within the uplands and the link between landscape and geological form and process is inescapable. Upland areas are characterised by their sub-surface geology and the level of resistance of each of the rock types to erosion. Superimposed onto this is a series of geomorphological processes that sculpt the shape of the land surface. In turn the geology and geomorphology of the landscape also dictate the nature of the soil cover, which determines the range of flora and fauna that the land is able to sustain.

For a relatively small country, England has a complex geological history clearly demonstrated by the diverse geology and landscape. In general the uplands of England comprise igneous rocks (crystallised from magma from the earth's centre) or metamorphic rocks (rocks recrystallised under heat or pressure) as they are more resistant to erosion than sedimentary rocks. However, more durable sedimentary limestones of the Pennines and the sandstones of the North York Moors.

4.2 The importance of earth heritage conservation

Britain was the birthplace of a great deal of geological thinking and research during the eighteenth and nineteenth centuries. Interpretation of geological history provides us with important information concerning climatic and environmental changes and demonstrates the link between geology and biology. Understanding our geological past is the key to interpreting our geological and environmental future. As such the conservation of a network of sites that interprets the evolution of our land mass is critical for our scientific, educational, cultural, aesthetic and economic development.

The geological evolution of the English uplands is demonstrated in Table 4.1.

Table 4.1 Geological evolution of the English Uplands

Geological Age (millions of years)	General rock types	Geo-environment and geological events relevant to the uplands	Upland area
Quaternary 'The Ice Age' 1.6-0.01	Screes, wind-blown and eroded material Boulder clays, river and melt-water deposits	Ice sheet cover with tundra-like conditions, erosion of the landscape and deposition of eroded material	All areas
	Peat, soils, river deposits	Temperate, non-glacial conditions	All areas
Tertiary 65-1.6	Sands and muds	Tropical weathering of sediments, karst development and the formation of the pre-Quaternary landscape	Landscaping effect on all uplands. Pockets of Tertiary sediments eg: Peak District.
Cretaceous 140-65	Chalk deposition under marine conditions	Pulling apart of the super-continent	Little impact on uplands as they were 'land' areas at this time.
Jurassic 195-140	Marine limestones and shales Non-marine sandstones	Flooded by warm seas Delta encroachment	North York Moors.
Permian & Triassic 280-195	Evaporates, sands and other desert deposits	Desert conditions with inland sea development	Pockets of sediments in uplands, eg: Penrith Sandstone, Cumbria.
Upper Palaeozoic - Carboniferous 345-280	Flooded peat beds (later transformed into coal seams), limestones and sandstones	Sea-level rise flooded much of the land surface	N. Pennines, S. Pennines Peak District, Forest of Bowland, Yorkshire Dales
	Volcanic rocks, folding and mineralisation	The Variscan mountain building episode, continued into early Permian	Dartmoor, Bodmin Moor, Pennines and the Peak District.
Upper Palaeozoic - Devonian 395-345		Erosion of land after Caledonian Orogeny and the opening of the Rheic Ocean	Igneous activity in the Cheviots and Lake District
	Marine muds and fossil-rich limestones		Exmoor
	Non-marine sandstones		Cheviots and Lake District

Geological Age (millions of years)	General rock types	Geo-environment and geological events relevant to the uplands	Upland area
Lower Palaeozoic - Cambrian, Ordovician & Silurian 570-395	Limestones, shales and sandstones	Widening and then closing of 'Iapetus', an ancient ocean which formed the proto-Atlantic'	Welsh Borders, Lake District
	Metamorphic rocks and igneous activity. Conversion of shales to slates by metamorphic activity	Caledonian mountain building episode	Slatey rocks of the Lake District. Igneous activity and folding in Shropshire, Pennines and the Lake District, with associated mineralisation.
Precambrian >570	Metamorphic rocks and volcanics. Sediment deposition		Welsh Borders

4.3 The evolution of England's upland landscape

The uplands have been continually evolving ever since their formation. They have been modified by the Ice Age and a series of geomorphological processes, such as the movement of material down-slope, river activity, karst landscape evolution and a range of other erosional and depositional processes. This modification occurs by way of breakdown of the rock or sediments by weathering agents, such as frost, wind and rain, and the redistribution of this eroded sediment by transporting agents, such as rivers, mass movement and wind. The result is a two-fold landscape; one that is dominated by erosion-forming the mountain areas, and another dominated by the deposition of material, on the valley sides and floors. These processes may change the form of the landscape slowly over centuries or through relatively rare catastrophic events, such as the landslip at Mam Tor, Derbyshire which caused the re-routing of the A625.

Human activity may also be regarded as a geological agent as it has had a tremendous impact on the British landscape. Mineral extraction, forest clearance, farming, transport, urbanisation and recreation have produced a 'cultural landscape' reflecting human intervention, even in the most remote upland areas.

As a result of this landscape evolution England's uplands may be divided broadly into six distinct areas of different geological character, all of which reflect the geological development of the English landscape. These are as follows:

- **Granite uplands**. This group includes Bodmin Moor and Dartmoor in the West Country, which are dominated by granite intrusions and mineral-rich deposits. During the Quaternary the area was subject to tundra-like conditions, which helped to sculpt the characteristic tor and boulder strewn landscape.

- **Precambrian and Lower Palaeozoic uplands**. This group includes the Shropshire Hills and Central Marches. The landscape comprises resistant Carboniferous rocks and early Palaeozoic sedimentary rocks and was subject to tundra-like conditions during the Quaternary period.

- **Late Palaeozoic uplands.** This group includes Exmoor and the Quantocks, Oswestry, Staffordshire Uplands, Black Mountains and the Golden Valley. The geology is solid Carboniferous and Devonian bedrock, overlain by Permo-Triassic deposits. The area was proximal to the ice sheets during the Quaternary and it is considered that localities such as The Golden Valley were formed through ice scouring the landscape. There are extensive deposits associated with the melting of ice and melt-water rivers.

- **Carboniferous Limestone and Millstone Grit uplands.** This group includes the Pennines, Peak District, Forest of Bowland and the Yorkshire Dales and is, in reality, a subset of the Late Palaeozoic Uplands, but has been placed in a second group due to its different management requirements. Mineral-rich water flowing through the limestone bedrock resulted in the formation of mineral rich veins. The landscapes in these areas are exposed and rugged with surface streams on the Millstone Grit and cave systems and potholes within the limestone bedrock. Ice sheets scoured the rock surface during the Quaternary, leaving it susceptible to weathering which aided the formation of characteristic limestone pavements.

- **Jurassic uplands**. This group includes the North York Moors with fossiliferous muds, shales and sandstones dominating the landscape. During the Quaternary the ice sheets deposited boulder clays, melt-water channels scoured deep into the bedrock and there is evidence of tundra conditions at the ice margins.

- **Caledonian uplands.** This group includes the Cumbrian Fells and Dales. The area has a mixed geology. Extensive erosion by the Quaternary ice sheets left only the most resistant rocks outstanding, for instance the Lake District Borrowdale Volcanic Group which forms the central Lake District hills.

4.4 The identification and selection of sites for earth heritage conservation

From the late 1940s until 1977 the most important earth heritage sites were identified by the Nature Conservancy, and then the Nature Conservancy Council, using information supplied by earth scientists. In 1977, the Geological Conservation Review (GCR) developed a systematic approach to site selection in Britain by identifying a network of sites that reflected the range and diversity of geology and geomorphological processes. Sites were selected between 1977 and 1990 and of all of the sites are notified as SSSIs. The criteria developed for site selection can be synthesised as follows:

- sites of importance to the international community of earth scientists;

- sites that are scientifically important because they contain exceptional features;

- sites that are nationally important because they are representative of an earth science feature, event or process which is fundamental to Britain's earth history.

The GCR classification scheme corresponds to seven 'categories' which correspond to periods of geological time or processes. Within these, individual 'sites' fall into subject 'blocks', so breaking the category down into more specific time periods or processes. For instance, the geomorphology category includes 10 'blocks' that allow subdivision of the geomorphological processes. A site such as the Mam Tor landslide, Derbyshire, would fall into the geomorphological 'category' and the mass movement 'block'. A full account of the GCR classification scheme can be found in the GCR Introductory Volume (Ellis *et al* 1996).

All earth heritage sites are classified as either *integrity* or *exposure* sites under the Earth Science Conservation Classification (ESCC). Integrity sites are those where the geology or landform is irreplaceable if removed or damaged and includes sites of limited extent and geomorphological sites. Exposure sites are those where the deposit is extensive and there is no immediate threat of the resource being lost.

4.5 Earth heritage objectives

Geological objectives for upland areas are derived from several sources including the English Nature Strategy, generic Natural Area geological objectives and key geological objectives for specific upland Natural Areas.

4.5.1 Earth heritage strategy

The English Nature leaflet entitled *Conserving England's Earth Heritage* is a good introduction to geological conservation highlighting English Nature's strategy for future work, under five headings:

- Managing and safeguarding the resource

  Including the completion of the SSSI and GCR site notification programme, site enhancement schemes and guidance for local Regionally Important Geological/Geomorphological Sites (RIGS) groups.

- Integrating earth heritage and the holistic approach

  Establishing closer working relationships with site owners and international partners to develop and share best practice.

- Influencing the influencers

  Production of best practice guidelines for Local Authorities and the inclusion of earth heritage conservation within the hierarchy of local plans.

- Raising awareness

  Striving to enhance the public's awareness of earth heritage through site interpretation schemes and publication at a range of levels of understanding.

- Involving the public

  Through public involvement we strive to increase public enjoyment and understanding, use established resources such as RIGS, the Geologists Association, local community and conservation groups.

4.5.2 Key geological objectives for upland areas

The key geological objectives for upland Natural Areas are as follows:

- maintaining and enhancing the geological resource through the enhancement of existing exposures, the use of site safeguard policies and the continued assessment of the scientific importance of sites;

- including earth heritage conservation features within Local Authority plans, National Park plans and the development of long-term conservation packages;

- promoting the English Nature position statement on fossil collecting (English Nature 1996) and emphasis of the need for responsible collecting at other sites including mines and tips, quarries and, where applicable, geomorphological sites;

- raising public awareness of the vulnerability of limestone pavements and the mechanisms in place to ensure their protection;

- supporting local caving groups in producing and implementing cave conservation plans and encouragement of local groups to take responsibility for specific cave systems;

- establishing initiatives for strengthening the links between English Nature and local communities through earth heritage conservation;

- establishing joint biological/geological management strategies for mixed interest sites and raise awareness of the link between geology and habitat development;

- promoting of the geological resource through the assessment of site educational value, on-site interpretation and the development of thematic trails.

More specific geological objectives have been developed for individual Natural Areas and may be found in the relevant Natural Area profiles which have been produced by English Nature.

Site classifications and examples of management options for earth heritage sites are outlined below. As with all conservation strategies, management needs to be site specific to take account of the uniqueness of the interest represented at each SSSI. Detailed management options for earth heritage sites are discussed more fully in the appendices of the *Earth Science Conservation in Great Britain, A Strategy* (Nature Conservancy Council 1991).

4.6 Site classification and examples of site management

4.6.1 Geomorphological sites

Geomorphological sites include three sub-groups of scientific interest in upland areas, active process sites, relict landform sites and karst landscapes. These are discussed in more detail below. Geomorphological sites are designated to provide examples of geological processes and systems that sculpt our landscape, and to conserve examples of rivers, slope failures, landforms, limestone pavements and caves. Sites in all three categories are classified as integrity sites as the interest may be easily damaged and is irreplaceable.

Active process sites

Active process sites include river and mass movement interest blocks. The management emphasis for active geomorphological sites is placed on maintaining the 'natural evolution' of the system. By their very nature geomorphological sites are active and evolving sites that may have social implications, for instance changing river patterns resulting from natural channel evolution or slope failure as a result of geological evolution of the landscape. As it is the natural evolution of the system that is important to the scientific interest of a site, management strategies should seek to minimise impacts on or changes to the natural system.

Human intervention is often incompatible with the effective conservation of these active sites as it is the naturalness of the geomorphological system that is scientifically important. In the uplands, rivers are generally free from the major human intervention common in lowland areas and are often accompanied by well documented histories in terms of local knowledge, historical records and photographs. In some cases it may be necessary to alter the natural system in some way, for instance engineering works to stabilise dangerous slopes in the interest of public safety or damage to property. In such cases the effects on the integrity of the site should be minimised and any changes that take place in the system should be recorded and monitored.

Some geomorphological activity is so catastrophic that attempts to curb the natural processes are abandoned and the sites are left to evolve naturally. At the well documented landslip site at Mam Tor, Derbyshire, the A625 road was destroyed during a series of landslips (Skempton, Leadbeater & Chandler 1989). Due to the extent of the movement and the likelihood of future activity, the road was diverted and the old road closed to traffic. The site, designated as an SSSI, is still an active landslip and has become a popular walking route with considerable educational opportunities.

Relict landforms

Relict or static geomorphological landforms are those that were formed during the Quaternary or Ice Age. They include glacial landforms such as tors and glacial ridges and features such as patterned and hummocky ground.

These sites require an integrated approach to management, taking account of the way in which the surrounding environment affects the site and ensures that development does not impinge on the scientific interest. Activities such as mineral extraction, tipping, in-filling, development and forestry are all likely to influence the scientific interest of these sites and appropriate consultation should be undertaken to ensure that alternatives are considered.

Karst

Karst sites are particularly vulnerable to damage and as such considerable detail has been paid to them in this handbook. Karst landscapes are those where the underlying geology is generally limestone. They are created by solution of limestone bedrock and are characterised by a landscape of surface hollows and depressions together with underground (rather than surface) drainage. The term karst derives from the German form of the Slovene word *kras,* meaning bare stony ground.

British karst landscapes can be found on both hard and soft limestones and include features of the chalk downlands as well as the hard limestone uplands. The most important karstic rock of Britain is the Carboniferous Limestone (Waltham *et al* 1997) which forms the upland blocks of Mendip, the White Peak, the Pennines and the Lake District fringes. A variety of features develop in karst topography of the uplands and these are discussed below.

- **Limestone pavements** are level or gently inclined bare limestone surfaces that are fissured by natural erosion demonstrating a pattern of blocks and fissures known as clints and grikes. Their basic structure results from glacial scouring but fine detail and patterning is a result of continuing geomorphological evolution. There is only 2,600 ha of pavement in Britain (Webb 1995) and it is known that only 3% of British pavements are undamaged (Ward & Evans 1976). Limestone pavements support a characteristic flora including a number of rare and scarce species (see Chapter 10 Crags, scree and limestone pavements). Over 90% of British pavements are found in northern England within Cumbria, North Yorkshire and the northern parts of Lancashire.

  Limestone pavements have been extensively damaged by the removal of stone for decorative garden rockeries. Provision was made in the Wildlife and Countryside Act 1981 for the protection of these features. Limestone Pavement Orders can be made under Section 34 of the Act which makes disturbance of the limestone a criminal offence. The orders have been very effective in reducing the amount of damage to the remaining limestone pavements in northern England. However, illegal damage and damage within areas with planning permission for quarrying continues. In 1995 the Limestone Pavement Action Group was established to reduce the demand for the water-worn rockery stone. Focusing on education and publicity the group has been very successful and has helped to secure revocation of two pavement quarrying planning permissions. Techniques to protect pavement have thus been focused on both preventing supply and reducing demand.

The management of limestone pavement and the impact of various agricultural regimes is discussed in Chapter 10. It is essential that the biological and geological interest of these features are considered together when devising management and protective strategies, as the conservation management of limestone pavements in the uplands must attempt to integrate the biological and geological interest of the features. In practice this is not difficult to achieve. Optimal management requirements for upland pavements are discussed in Chapter 10 but in general will centre on a reduction of grazing pressure. Ingleborough and Great Asby Scar National Nature Reserves are examples where grazing stock have been excluded from pavement areas. These sites are nationally important for both their botanical and geological features. The change in vegetation resulting from the exclusion of the grazing stock has not resulted in the loss or obscuring of geological features. It is important to remember that these pavements are active geomorphological sites which display a relationship between vegetation cover and physical form.

- **Cave systems** are an important feature of upland karst areas. They are formed where there is an available flow of water with the potential to dissolve limestone and a hydraulic gradient between the top and bottom of a cave. The cave passages, and the sediments and speleothems (stalactites, etc) within them, are fragile features and as such are regarded as integrity sites. They have taken thousands of years to form and many pre-date the last ice age. The sediments and speleothems within the caves, as well as the physical form and shape of the passages, add significantly to our understanding of the geological evolution of the English uplands. Caves often contain important environmental and archaeological deposits that improve our knowledge of past climates. Caves also support rare fauna such as bats or troglobites (species adapted to living in permanent darkness).

Cave entrances and catchments are generally included within the SSSI boundary. Caves are important local drainage routes and changes to the hydrological catchment (drainage, abstraction, etc) can have an impact on the condition of the cave, its sediments and decorative speleothems. It is therefore important that caves are viewed as systems, together with their catchment areas rather than as isolated passages.

Damage to cave environments can be averted through appropriate management of the cave catchment area. Practices such as moor gripping, afforestation, deforestation or modification to water courses can all affect the cave, its sediments and speleothems. Threats to caves include recreational damage, physical loss (through quarrying, mining or waste disposal) and changes in hydrology or catchment.

Damage caused by recreational use by cavers generally has an impact on sediment deposits and speleothems rather than on the physical form of the cave itself. The National Caving Association (NCA) published a conservation policy in 1995 and has a code of conduct for cavers. The conservation policy, which was supported by English Nature, identifies cave conservation plans as a valuable tool to secure the conservation interest of caves. These site-specific plans are devised, supported and implemented by the cavers who know and use the site. The NCA policy also addresses external threats to caves such as quarrying, landfill and water abstraction. The threats are best addressed through the minerals planning process, development plans and responses to individual planning applications.

In the cave conservation plan produced for Lathkill Head Cave, Derbyshire two levels of threat were identified: internal and external. The internal threats came from usage of the cave system while external threats were identified as changes in the catchment hydrology and therefore water movement within the system. As a result recommendations were made to safeguard the areas of the cave system that were most at risk and a number of issues were highlighted for further investigation, including the use of information boards to inform cavers of the threats to the system and moves to limit the amount of litter left within the system.

- **Other karst features** found in the uplands include shakeholes or depressions, scars, scree and dry valleys. These features are separate parts of a mosaic which makes up the karst landscape. They are often physically linked and in many cases the processes are still active and the features are still evolving. As well as providing information about the evolution of the post-glacial landscape these features are often of botanical importance with thin soils, species-rich grasslands and a variety of rock habitats (see Chapter 10).

  Karst features such as shakeholes or depressions, scars and scree are vulnerable to agricultural impacts especially where they lie within enclosed land. Infilling of depressions and shakeholes with agricultural rubbish has been a continuing problem especially on the Mendip Hills (Stanton 1992) where these depressions form convenient receptacles for a variety of farmyard waste. The result is a permanent loss of the landform and a potential pollution threat, as many of the depressions link directly to underground drainage.

  Scars, screes and limestone pavements form a useful source of hardcore or building stone. Whilst it may be acceptable to find material for wall gapping or track maintenance from these features, the scale of removal needs to be balanced with a permanent loss of feature. Best practice will centre on management agreements and discussing stone sources with the landowner or tenant.

Further information: Watson 1997

4.6.2 Mines and mine dumps

Igneous activity and the movement of water through rocks can leave behind mineral-rich deposits. For centuries man has exploited these mineral veins. Mines and their associated waste material are of geological significance as they provide us with information relating to the formation of the surrounding area and the geological evolution of Great Britain. The associated waste material often provides a safe study site as an alternative to abandoned mines, which may be flooded or too dangerous to enter. Consequently mine dumps are often the only possible location to study and collect certain rocks and minerals.

To maintain the geological interest of these sites access to and direct contact with the mineralised deposits is critical. Close examination of the mined material can be achieved by utilizing spoil tips. In cases where development pressures result in damage to the scientific interest of these spoil heaps it may be necessary to move the spoil tip to another location. However, although this will conserve some of the scientific interest, it is less desirable than maintaining the interest *in situ*. Responsible collecting of material is encouraged by English Nature and the Geologists Association code of conduct should be adhered to when visiting such sites.

4.6.3 Disused quarries

Disused quarries have the potential to provide excellent geological exposures which may have been difficult to access during normal quarrying operations. These exposures provide us with information relating to the geological evolution of Britain. In general these quarries are classified as exposure sites, as an area of the scientifically important material remains as an unexcavated reserve on the quarry margin. In those localities where the deposits are of outstanding importance or are limited in their extent, the sites are classified as integrity sites.

A range of after-uses is possible for disused quarries, including nature conservation, development, landfill and reservoir formation. If the entire quarry is being used as a geological nature reserve, the rock faces should be kept safe and cleared of vegetation and slumped material (scree) as and when necessary. If an application is made to fill a site it is usual that English Nature will enter into negotiations with the landowner to secure a permanent exposure within the quarry which is representative of the interest at the site.

Positive management of the geological interest requires that physical and visual access to the geological sections should be maintained. Commonly in disused quarries, the geological face and scree may become a haven for wildlife and any works undertaken to re-expose the geological section should be balanced with all conservation interests at the site, including any biological or entomological interest. In addition operations considered as normal practice during mineral extraction may now be found on the list of operations likely to damage the scientific interest.

A good example of earth heritage conservation as an after-use is Burrator, Dartmoor, where a series of disused quarries has been designated as an SSSI. The site is accompanied by a geological trail which examines the range of landforms associated with tor formation and the evolution of the Dartmoor landscape. The trail is designed for both specialists and interested non-specialists. Further information about the site may be found in the Nature Conservancy Council publication *Burrator, Dartmoor landform trail* (Keene & Harley 1987).

4.6.4 Active quarries

Active quarries are important for earth heritage conservation as the exposures provide us with information relating to the geological evolution of Britain. Mineral extraction creates new geological sections, so revealing new material and scientific information on a regular basis and provides the opportunity to create a permanent conservation face for study. It is acknowledged that active quarries may modify the landscape unacceptably. Mineral extraction may be compatible with geological conservation provided that discussion is entered into concerning the location, size and management of permanent sections.

Active quarries are generally classified as exposure sites. As with disused quarries site management should address maintaining access to the geological interest. Early consultation with English Nature can help to ensure that geological conservation is integrated with extraction and restoration schemes for the site and to identify the optimum location for a permanent section that displays the necessary information for site interpretation.

At Shap Quarry, Cumbria, the zoned mineralisation seen in the rocks is the result of igneous and metamorphic activity. Owing to the nature of the extraction process and the danger of falling rocks the quarry company has allowed limited access to the site and provides a 'safe' area where prepared blocks of the material can be viewed. It is hoped that when quarrying is completed a permanent exposure will be left in the quarry face.

4.6.5 Natural upland exposures and outcrops

Natural upland exposures and outcrops include sites of geological interest ranging from natural rock outcrops, through to peat deposits and frost shattered material. Next to coastal cliff sections England's uplands provide the most extensive natural exposures and are therefore critical to developing our understanding of the geological evolution of Great Britain.

As with many geological sites, once the interest has been damaged or destroyed it can not be replaced. Due to the range of geological sites included within this group it is difficult to generalise about appropriate site management. However, the general emphasis should be placed on assessing the scale of the impacts, maintaining natural exposures and restricting damage to the geological interest. Examples are given below:

- Recreational activity, such as rock climbing, can be severely damaging to upland geological exposures. The British Mountaineering Council (BMC) is researching techniques to minimise rock edge erosion and is campaigning to educate climbers about responsible climbing techniques and the scientific importance of sites.

- Peat erosion can occur for a number of reasons including footpath erosion and vegetation loss. The restoration of eroded peat may be ecologically beneficial but for sites designated for their geological interest the scientific importance lies in the actual organic material contained within the peat which provides important climatic information, some of which would have already been lost through erosion. Revegetating the peat to slow down the rate of erosion is the most effective restoration technique and would be the preferred geological management option. Some peat exposure and erosion may be the result of natural processes and evolution of the geological system and for this reason management decisions should be site specific based on the extent of the deposit and the causes and rates of erosion.

- Scree deposits are susceptible to footpath erosion. Repair and restoration of scree slopes should be by natural recharge from the higher areas, as the import of ‘fresh’ material will destroy the structure of the slope, the slope angle and down-slope sorting of material.

Moor House and Cross Fell SSSI, Cumbria is a large geological site with a range of interests including karst, fluvial and peat sites. Part of the site is also biologically important and is a NNR. Access to the peat bog area is restricted, which safeguards the scientific interest. The Pennine Way crosses the site and footpath erosion is therefore a potential threat, but early consultation with English Nature will allow management options to be discussed.

4.6.6 Road and railway cuttings

Roads and railway cuttings can provide extensive exposures often lacking in inland Britain. These exposures provide us with information relating to the geological evolution of Britain and may be temporary (occurring only during construction) or permanently designed cuttings, such as the Tebay Road cutting SSSI, Cumbria.

Cuttings are generally classified as exposure sites and in order to manage the scientific interest of the site, access to the geological faces should be maintained. Early consultation with English Nature and inclusion of the geological interest within the road design can be used to address issues of access and safety. The English Nature reports on Roads and Geological Conservation (English Nature 1994; Larwood & Markham 1995) discuss the use that cuttings play in earth heritage conservation and examines good practice and techniques available to overcome the geological and geomorphological complications that may arise as a result of creating permanent exposures.

Construction of the Tebay road cutting, Cumbria cut through marine sandstones deposited 415 million years ago. Permanent exposures were designed into the road scheme and exposures have been left along the M6 and the A685, with access made for study purposes along the A road site. Management of this site is minimal, mainly because the rocks are not subject to slumping or collapse.

4.7 Advice on earth heritage conservation

Advice on earth heritage conservation may be sought from both English Nature local area teams and the geological specialists in the Peterborough office. A number of documents are also available covering aspects of earth heritage conservation and these are referenced in Chapter11.

Local geological conservation can be addressed through the RIGs. Contact with groups relevant to upland issues, such as the National Caving Association or The Limestone Pavement Action Group, is also recommended.